

RESEARCH ARTICLE

Informing climate adaptation for women's and children's health: A cross-sectional survey on knowledge, attitudes, and practices in a climate-vulnerable setting

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Abstract

Women in low- and middle-income countries, including Indonesia, are disproportionately affected by climate change impacts. Despite the intersection of these risks with gender inequalities, evidence on women's knowledge, perceptions, and responses are limited. This study established baseline data on Indonesian women's knowledge, attitudes, and practices regarding climate change and its health impacts. A cross-sectional 33-item survey adapted from the United Nations Development Programme's Climate Change Knowledge, Attitudes, and Practices Survey was administered electronically and in person between July 2023 and May 2024. Descriptive statistics summarised responses, and Pearson's chi-square tests assessed associations between demographic characteristics and knowledge, attitudes, and practices. Among 941 participants, 723 (76.8%) were university graduates, 682 (66.0%) lived near disaster-prone areas, 576 (61.2%) were married, and 556 (59.1%) were employed. Educational level was significantly associated with knowledge of climate change causes and effects ($p < 0.001$, 95% CI = 0.000–0.000), whereas no demographic variables were associated with knowledge of climate-related health impacts. Awareness of gender-specific health risks remained low, with few participants recognising risks such as preterm birth ($n = 256$; 27.2%) and increased vulnerability to sexual violence ($n = 119$; 12.6%). Attitudes toward climate change were associated with education level ($p < 0.001$, 95% CI = 0.000–0.000) and place of residence ($p = 0.003$, 95% CI = 0.002–0.004). Engagement in mitigation practices was associated with occupation ($p = 0.003$), marital status ($p = 0.018$, 95% CI = 0.015–0.020), and education level ($p < 0.001$, 95% CI = 0.000–0.000), but not residence ($p = 0.661$, 95% CI = 0.652–0.670). Although Indonesian women expressed concern

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and motivation to address climate change, knowledge gaps exist regarding its gendered health impacts. Targeted climate–health communication and locally relevant adaptation strategies are needed to strengthen the resilience of women and children in vulnerable communities.

Introduction

Climate change is a defining threat to global health, with mounting evidence of its disproportionate impacts on women and children in low-resource settings, particularly in low- and middle-income countries (LMICs) [1,2]. These health risks intersect with pre-existing gender-based inequalities and limited adaptive capacity, increasing vulnerability to extreme weather events, food insecurity, vector-borne diseases, and disruptions in reproductive, maternal, and child health services [3,4]. The global agenda on climate and health, reflected in the Sustainable Development Goals (SDGs), particularly SDG 3 (Health), SDG 5 (Gender Equality), and SDG 13 (Climate Action) [5], the United Nations Framework Convention on Climate Change (UNFCCC) Gender Action Plan [4], and the World Health Organization's (WHO) Global Strategy on Health, Environment and Climate Change [6], calls for strengthened, inclusive evidence to inform gender-responsive climate adaptation and resilience strategies and public risk communication. Furthermore, the Global Action Plan on Climate Change and Health further emphasizes the need for inclusive, community-driven data to design equitable climate-health responses [2]. Similarly, the Intergovernmental Panel on Climate Change (IPCC) concluded that gender inequality is a critical factor shaping differential exposure to climate hazards and adaptive responses [1]. However, empirical data capturing women's perspectives remain limited, particularly in climate-vulnerable regions of Southeast Asia. Specifically, there is limited insight into how women in LMICs perceive climate-related health risks to women and children and how women access the climate and health information necessary to support adaptive decision-making and informed community-led action to protect women's and children's health [3].

Indonesia is one of the most climate-vulnerable countries globally, comprising over 17,000 islands, 6,000 of which are inhabited by more than 278 million people. Its diverse topography includes coastal lowlands, mountainous terrain, and extensive rainforests, and it is situated along the seismically active Pacific Ring of Fire [7]. The country experiences increasing climate-induced hazards, including sea-level rise, flooding, saltwater intrusion, ecosystem degradation, and more erratic wet and dry seasons [7,8]. Environmental degradation, including deforestation driven by agriculture and industry, exacerbates greenhouse gas emissions, biodiversity loss, and public health risks. Climate change in Indonesia also contributes to the spread of vector-borne diseases (e.g., dengue, malaria), respiratory illnesses from air pollution and forest fires, and increased incidence of waterborne diseases due to poor sanitation and water quality [9]. Unsurprisingly, these climate-sensitive health risks

disproportionately affect Indonesia's most vulnerable populations, including women, children, low-income communities, ethnic minorities, migrants, the elderly, and those with pre-existing health conditions [7–10].

For Indonesian women, additional complexities arise from prevailing social and cultural norms and societal roles, including constrained decision-making, limited acceptance of women as leaders, limited employment opportunities after marriage, and restricted career advancement [10,11]. Climate-driven hazards further heighten the risk of physical and emotional violence against women [10]. Due to Indonesian women's societal roles and pre-existing vulnerabilities in the context of climate change [10,12], they disproportionately experience challenges related to sexual and reproductive health, domestic violence, and access to maternal and child health services, resulting in increased risk of adverse pregnancy outcomes such as increased maternal mortality, low birth weight, and maternal and child malnutrition [13]. In rural areas, the physical demands of agricultural and domestic labour during extreme heat are also associated with adverse maternal and fetal health outcomes [14].

A lack of studies and policies in Indonesia focusing on the connection between climate change and women's and children's health further reduces their visibility in this context, and subsequently increases their physical and mental health risks, possibly hindering their capacity to act as primary caretakers [15]. Women are already instrumental in climate change resilience in Indonesia, as they play an active role in protecting family and community health, often as informal caregivers and as volunteer community health workers focusing on maternal and child health [10–12]. Specifically, they support climate resilience through maternal and child health activities, health promotion, and community outreach by disseminating health information, monitoring vulnerable populations, and facilitating early responses to climate-sensitive illnesses, thereby strengthening adaptive capacity at household and community levels [4,10,13,16]. However, their contributions remain under-recognised in climate-health planning, and their perspectives are rarely centred in policy or research. A lack of gender-disaggregated data and evidence-informed strategies further limits women's visibility and capacity to adapt, increasing health risks while also weakening the resilience of the broader community.

Given their substantial roles in the Indonesian community, improving women's knowledge, skills and tools to respond to climate-related health risks is essential. To support this goal, we need to understand Indonesian women's baseline knowledge, attitudes, and practices regarding climate change and its health impacts. Aligning with the UNFCCC Gender Action Plan [4] and the Sustainable Development Goals (SDG 3 – Health, SDG 5 – Gender Equality, and SDG 13 – Climate Action) [5], this study addresses a critical evidence gap by examining how Indonesian women in climate-vulnerable settings perceive and respond to the health impacts of climate change. Specifically, we explore Indonesian women's knowledge of the causes of climate change and its impacts on health, their attitudes toward climate change, and their engagement in proactive mitigation practices, and then assess the associations of these factors with demographic characteristics. In addition, we explore women's perceptions of climate change's impacts on their local environment and personal health, and how they access information on climate and health. These findings can inform gender-sensitive public health interventions and support climate adaptation and resilience efforts in Indonesia and comparable high-risk contexts.

Methods

Ethics statement

Ethical approval was obtained from Universitas Indonesia (KET-205/UN2.F12. D1.2.1/PPM.00.02/2023) and the Health Research Ethics Committee of the Indonesian National Research and Innovation Agency (102/KE.03/SK/09/2023).

Study design and participants

A prospective cross-sectional study was conducted across Indonesia between July 2023 and May 2024 and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines ([S1 Checklist](#) STROBE Checklist) [17]. Women aged 18 or older were eligible to participate

and needed to be literate in Bahasa Indonesia. Based on the Slovin formula with a 4% margin of error [18] and a total population of approximately 137 million Indonesian women [19], the minimum required sample size was 625 participants.

Data collection

Participants were recruited through social media poster advertisements and community visits. The advertisement included a QR code and a link to the survey, allowing direct access. To incentivise participation, 40 randomly selected respondents were eligible to win a 50,000 IDR gift voucher through a separate, unlinked process to ensure anonymity. To improve inclusivity, when research teams visited communities, participants were approached in person and given an opportunity to complete the survey anonymously either via SurveyMonkey or on paper format. Where women had low literacy, the research team members assisted them in completing the survey.

Survey development and piloting

The survey was adapted from the United Nations Development Program (UNDP) Climate Change Knowledge, Attitudes, and Practice Survey [20], which measures general knowledge of climate change, attitudes to climate change, and identifies actions taken by the community to address climate change and barriers to climate change action. The survey adaptation included the addition of health-related questions. The survey was professionally translated into Bahasa Indonesia and validated with 33 participants from diverse demographics, primarily those with higher education and an average age of 31. These same 33 participants then completed the revised survey, and Cronbach's alpha test was used to assess internal consistency. Following pilot testing, internal consistency of the instrument demonstrated good reliability ($\alpha = 0.846$). The final survey consisted of 33 questions (S1 Table), including 15 demographic questions, three questions on knowledge (which were divided into two questions about general knowledge of climate change and a question about health-related impacts of climate change), five questions on attitude, three questions on practice, four questions on impacts, and three questions on information access. For some questions, more than one answer was permitted; therefore, some responses may exceed 100% response rate.

To assess women's knowledge, the survey [20] consisted of three closed-ended questions with eight response options for the causes of climate change, twelve for climate change-related phenomena, and twenty-seven for climate change-related illnesses. To assess women's attitudes toward climate change, the survey consisted of five questions utilising Likert-type scales with response options ranging from 1 (not important) to 3 (very important). Two questions assessed women's concern and interest in climate change issues and action. The remaining questions evaluated women's perceptions of the significance of ten specific activities addressing climate change impacts on the local environment, women's agreement on five recommended actions that stakeholders could undertake, and eight actions related to addressing climate change impacts.

To identify climate-related practices [20], women were asked if they engaged in activities to address climate change, by identifying which of 14 activities they implemented and which six obstacles they faced. The survey further included government actions related to climate change, listing nine activities for selection. The survey included two Likert-scale questions and one multiple-choice question about accessing climate change information. The Likert scales measured the frequency of media access (1 = never, 2 = seldom, 3 = often) and the level of interest (1 = not interested, 2 = interested, 3 = very interested). The multiple-choice question listed 16 sources of climate change information for participants to select from. The survey evaluated the health and environmental impacts of climate change through four questions. Two questions explored the lived experience of disasters across nine categories and their health impacts, allowing for multiple responses, and two questions addressed personal significance and self-reported health status using "yes" or "no" responses.

Data analysis

Surveys containing only demographic responses were excluded, while partial responses were included. Missing answers were coded as 999 and also excluded. Descriptive statistics (frequencies and percentages) were used to summarise participants' characteristics. Associations between categorical variables were assessed using Pearson's chi-square test. The data were analysed using IBM SPSS Statistics version 23. A p-value of less than 0.05 was considered statistically significant. All estimates were presented with 95% confidence intervals (95% CIs). As this analysis was designed to identify associations rather than estimate effect sizes, odds ratios were not calculated; instead, p-values and confidence intervals are reported in accordance with statistical guidance for association-focused models [21]. Consistent with the UNDP Knowledge, Attitudes and Practices (KAP) Survey [20], survey items were analysed individually rather than combined into composite knowledge or attitude scores. This approach allowed identification of specific knowledge gaps and variations in perceptions related to climate change and health. All statistical analyses are presented in [S1 Data](#).

Disclosure of AI use

Grammarly Pro without generative AI assistance was used to proofread and check grammar, syntax and clarity whilst preserving the authenticity of the human thought process.

Results

Participants demographics

Of the 1,112 participants who accessed the survey, 941 were included in the analysis ([Fig 1A](#)). Most participants were from western Indonesia ($n=627$; 66.6%), lived in coastal areas, lowlands, or highlands ($n=682$; 66.0%), and were married ($n=576$; 61.2%). The majority were employed ($n=556$; 59.1%) and university graduates ($n=723$; 76.8%). Detailed socio-demographic characteristics are summarised in [Table 1](#).

Knowledge of climate change causes

A total of 941 participants completed this question. Most participants identified five primary causes of climate change: vehicle pollution from private transportation ($n=889$; 94.5%), inadequate industrial practices ($n=887$; 94.3%), deforestation and mangrove destruction ($n=868$; 92.2%), littering ($n=829$; 88.1%), and fossil fuels ($n=824$; 87.6%). However, over half of the participants perceived climate change as God's will ($n=630$; 67.0%) or attributed it to natural causes ($n=572$; 60.8%) ([Fig 1B](#)). Women recognised that climate change events are linked to changes in weather patterns ($n=922$; 98.0%), extreme increases in ambient temperature ($n=910$; 96.7%), and rising air pollution ($n=878$; 93.3%) ([Fig 1C](#)). A chi-square test showed that participants' knowledge of climate change causes had a significant association only with their education level ($p<0.001$, 95% CI=0.000–0.000); it was not significantly associated with their occupation ($p=0.084$), marital status ($p=0.976$, 95% CI=0.973–0.979), and residence ($p=0.595$, 95% CI=0.585–0.605).

Knowledge of climate change impacts on health

Indonesian women ($n=941$) recognised physical illnesses related to climate change, including respiratory diseases ($n=912$; 97.0%), sunburn ($n=861$; 91.5%), skin diseases ($n=760$; 80.8%), and dengue haemorrhagic fever ($n=728$; 77.4%). However, fewer connected climate change with women and children's health issues, such as sexual violence ($n=119$; 12.6%), menstrual disorders ($n=222$; 23.6%), gestational hypertension ($n=251$; 26.7%), preterm birth ($n=256$; 27.2%) and stunting ($n=300$; 31.9%) ([Fig 1D](#)). A chi-square test demonstrated that knowledge of climate-related health impacts had no significant association with any of the demographic characteristics, i.e., occupation ($p=0.755$), marital status ($p=0.186$, 95% CI=0.178 - 0.194), education level ($p=0.121$, 95% CI=0.115 - 0.127), and residence ($p=0.996$, 95% CI=0.995 - 0.997).

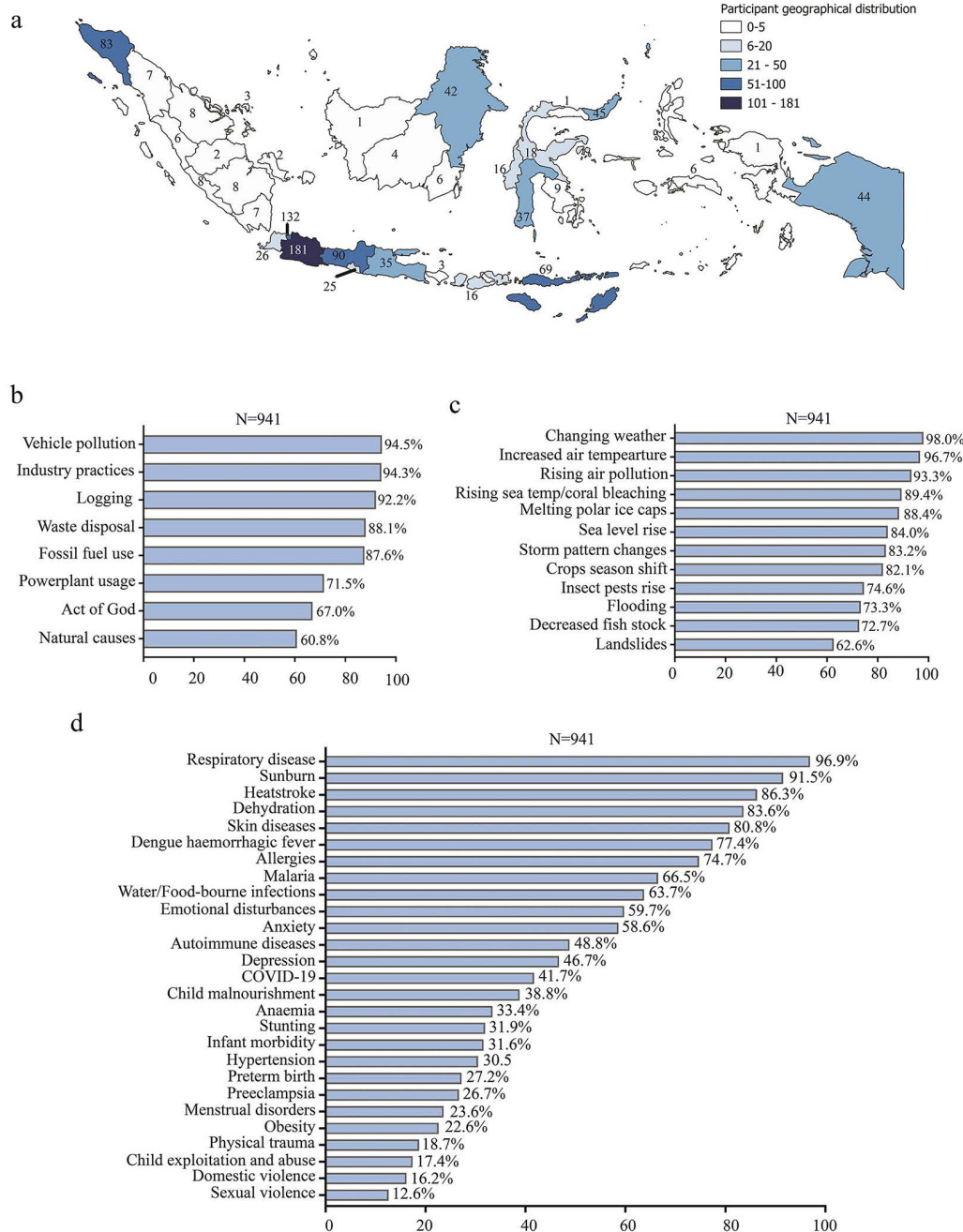


Fig 1. Climate change knowledge among study participants in Indonesia. (a) Geographic distribution of study participants across Indonesian provinces (N=941). Provinces are shaded according to the number of participants recruited from each province. Provincial boundaries were derived from the Natural Earth Admin-1 States and Provinces dataset and visualised using QGIS (version 4.1). Natural Earth map data are in the public domain and available from <https://www.naturalearthdata.com>. (b) Knowledge of the main causes of anthropogenic climate change. (c) Knowledge of environmental changes associated with climate change. (d) Knowledge of the impacts of climate change on human health.

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Table 1. Participant demographics. *denotes that more than one answer was permitted in this category.

Participant demographics	n (%)
Employment (n=941)	
Employed	556 (59.1)
Unemployed	385 (40.9)
Residence (n=941)	
Western Indonesia	627 (66.6)
Central Indonesia	263 (28.0)
Eastern Indonesia	51 (5.40)
Duration of residence (n=941)	
< 1 year	68 (7.20)
1 - 5 years	240 (25.5)
5 – 10 years	120 (12.8)
10 – 15 years	82 (8.70)
15 – 20 years	78 (8.30)
> 20 years	353 (37.5)
Marital Status (n = 941)	
Married	576 (61.2)
Not Married	337 (35.8)
Divorced	28 (3.00)
Education (n = 941)	
Higher	723 (76.8)
Middle	159 (16.9)
Basic	57 (6.10)
None	2 (0.20)
Location of Residence (n = 1033) *	
No	351 (34.0)
Near River	219 (21.2)
Lowlands	186 (18.0)
Coastline	160 (15.5)
Highlands	117 (11.3)
Insurance (n = 1007) *	
Public insurance	866 (86.0)
Private insurance	87 (8.60)
None	54 (5.40)

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Attitudes toward climate change

Of the 923 participants, just over half (n=504; 54.6%) expressed a high level of concern about climate change impacts on the environment (Fig 2). Most believed that effective measures for mitigation include increasing tree planting (n=818; 88.6%), reducing deforestation (n=803; 87.0%), improving public awareness of climate change issues (n=715; 77.5%), and boosting community participation (n=640; 69.3%) (Fig 2A). Participants agreed that action must be taken by local governments (n=744; 80.6%), central governments (n=741; 80.3%), and community members (n=713; 77.2%) to address climate change (Fig 2B). Additionally, most (n=588; 63.7%) were willing to engage in environmental conservation efforts and believed that everyone is responsible for the country's environmental conservation (n=860; 93.2%). Over half of the participants (n=516; 55.9%) expressed a strong interest in learning more about the impacts of climate change. A

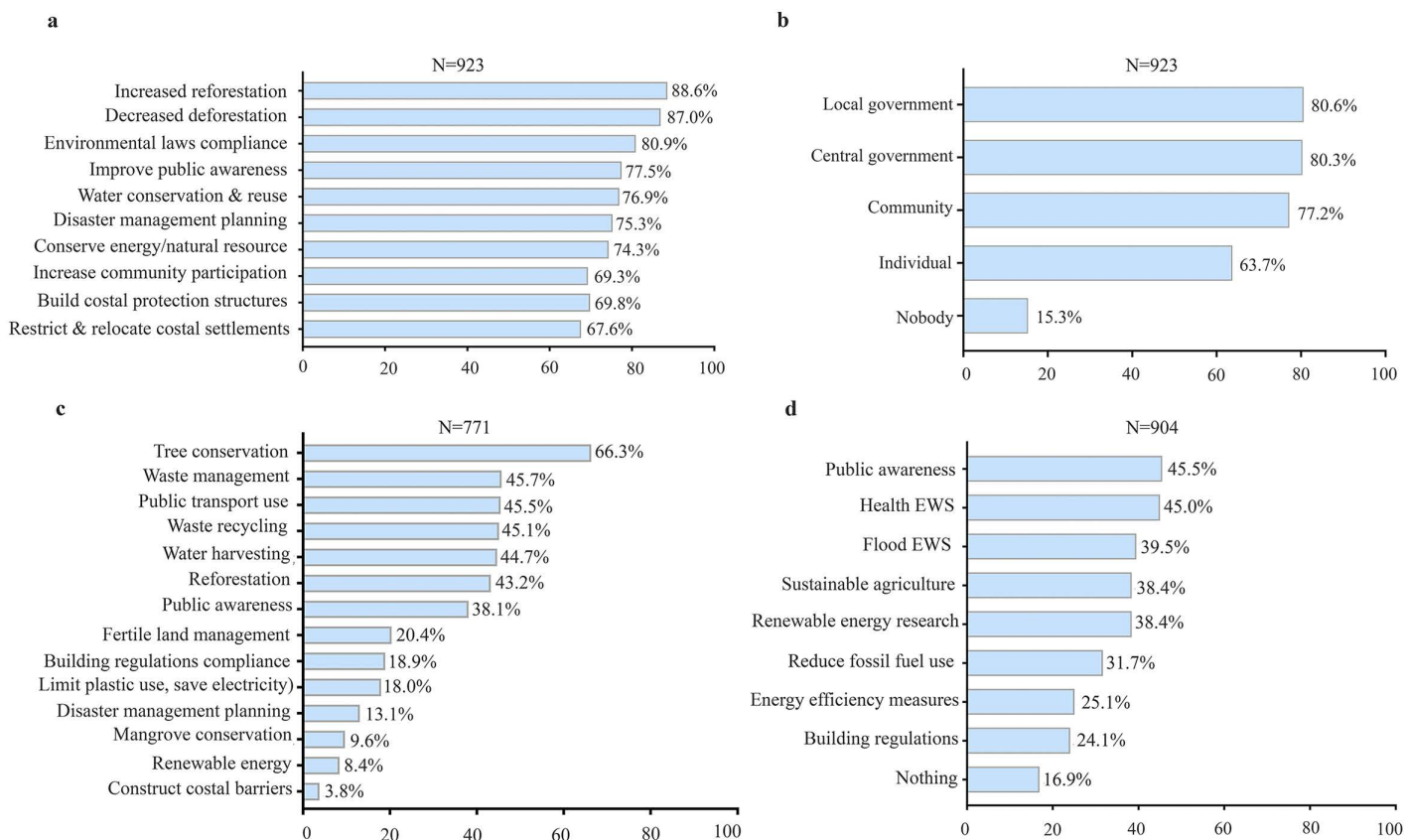


Fig 2. Participants' attitudes, beliefs, and actions related to climate change mitigation. (a) Attitudes toward climate change mitigation actions. (b) Beliefs about who is responsible for undertaking mitigation actions to reduce climate change impacts. (c) Self-reported engagement in climate change mitigation actions. (d) Awareness of national initiatives supporting climate change mitigation and the prevention of climate-related harms.

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chi-square test showed that participants' attitude toward climate change had a significant association with their education level ($p < 0.001$, 95% CI = 0.000–0.000) and residence ($p = 0.003$, 95% CI = 0.002 - 0.004), whereas it was not significantly associated with their occupation ($p = 0.095$) and marital status ($p = 0.706$, 95% CI = 0.697 - 0.715).

Practices of climate change mitigation

Most participants ($n = 774$; 83.8·8% of 922 respondents) took proactive measures to mitigate climate change impacts in their communities (Fig 2). Among 771 respondents to a follow-up question, the three top actions included refraining from indiscriminate tree cutting ($n = 511$; 66.3%), proper waste management ($n = 352$; 45.7%), and using public transportation ($n = 351$; 45.5%) (Fig 2C). Barriers to action ($n = 146$) included lack of awareness of available measures ($n = 33$; 22.6%), insufficient information ($n = 38$; 26.0%), and a combination of lack of awareness and inability to act ($n = 67$; 45.9%) (Fig 2c). Participants ($n = 904$) recognised several government initiatives to address climate change, including increasing public awareness ($n = 411$; 45.5%), developing early warning systems for health ($n = 407$; 45.0%) and natural hazard ($n = 357$; 39.5%), and promoting renewable energy research and use and environmentally sustainable agriculture ($n = 347$; 38.4%) (Fig 2D). A chi-square test revealed that participants' practice of climate change mitigation had a significant association with their occupation ($p = 0.003$), marital status ($p = 0.018$, 95% CI = 0.015–0.020), and education level ($p < 0.001$, 95% CI = 0.000–0.000), while it was not significantly associated with their residence ($p = 0.661$, 95% CI = 0.652–0.670).

Self-reported impacts on women's health

When reflecting on the past year and conditions that might have impacted their health, women (n=881) reported experiencing respiratory diseases (n=727; 82.5%), sunburn (n=453; 51.4%), and dehydration (n=434; 49.3%). Fewer women reported menstrual disturbances (n=242; 27.5%), pregnancy hypertension (n=63; 7.2%), premature birth (n=45; 5.1%), domestic violence (n=48; 5.4%) and sexual violence (n=45; 5.1%) (Fig 3).

Climate change impacts on the environment

When asked about disasters in their communities over the past 10 years, participants (n=900) identified flooding (n=517; 57.4%), earthquakes (n=368; 40.9%), and drought (n=290; 32.2%) as the main events (Fig 4A). Exposure to these events led participants (n=777) to report negative impacts on environmental cleanliness (n=538; 69.2%), and an increase in infectious (n=450; 57.9%), and respiratory diseases (n=353; 45.4%) (Fig 4B). Additionally, participants (n=881) believed that climate change affected their local environments by altering weather patterns (n=848; 96.3%), increasing air temperatures (n=833; 94.6%), and rising cases of waterborne and airborne diseases (n=750; 85.1%), drought (n=621; 70.5%), and flooding (n=550; 62.4%) (Fig 4C).

Access to information on climate change

Among the 873 participants who responded to questions about access to climate and health information, most (n=514; 58.9%) reported rarely encountering climate change information. However, a strong interest in learning more about climate-related topics (n=772; 88.4%) was evident. Most participants accessed climate change information via the internet (n=764; 87.5%) and television (n=444; 50.9%), while fewer relied on friends and family (n=209; 23.9%), schools (n=40; 4.6%) or religious groups (n=27; 3.1%).

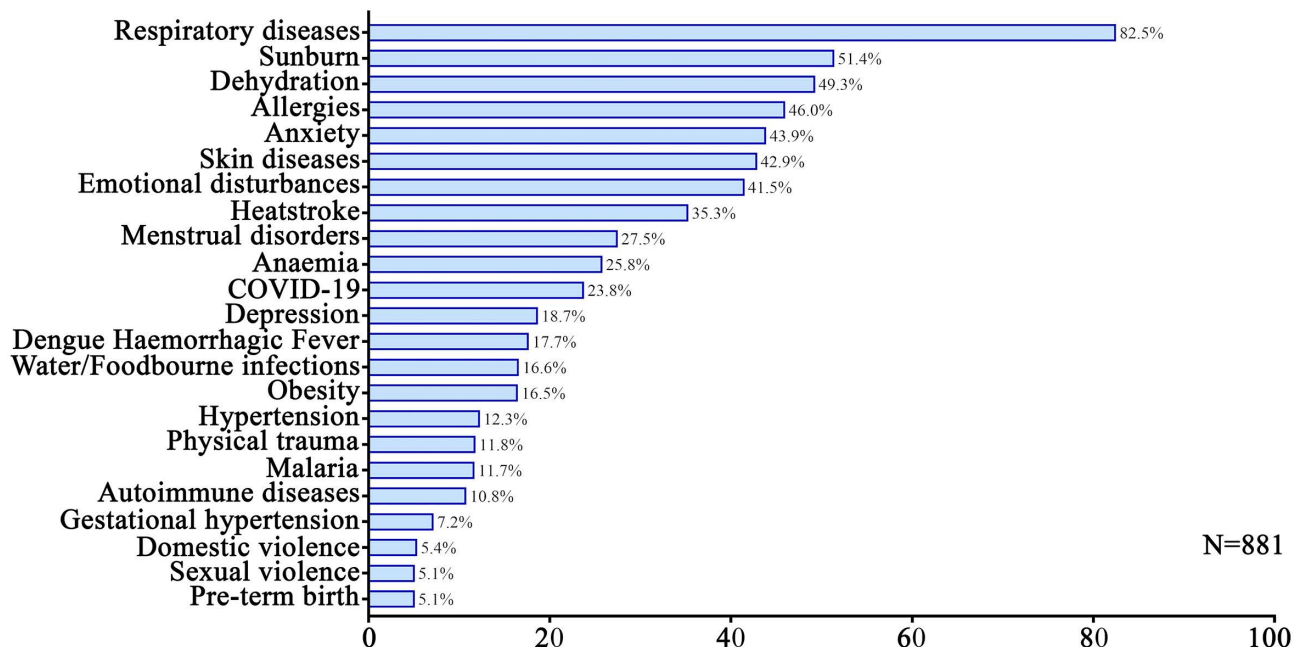


Fig 3. Self-reported health challenges experienced by participants in the 12 months prior to the survey.

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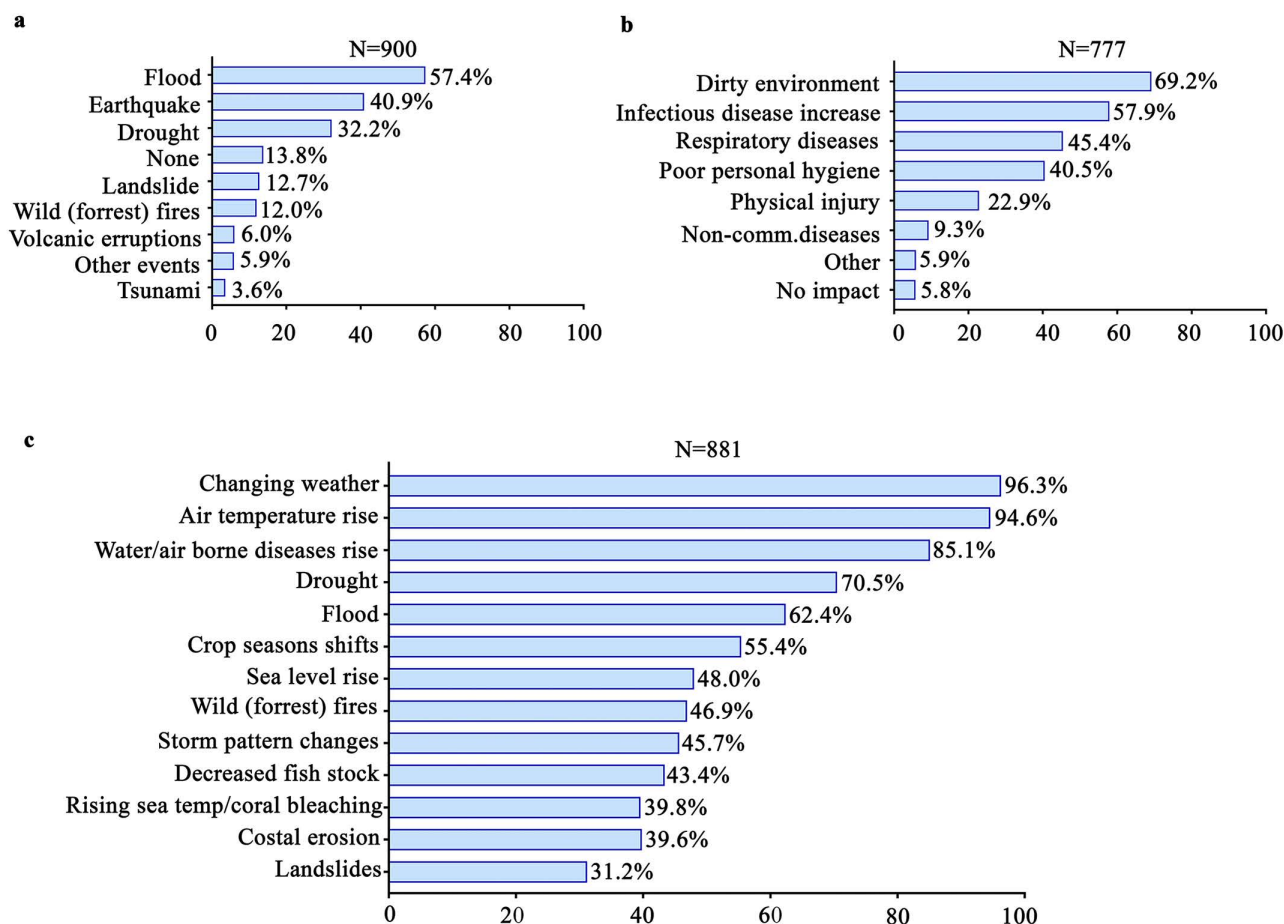


Fig 4. Women's awareness and perceptions of climate-related natural hazards. (a) Awareness of natural hazard-related events occurring in participants' local environments during the 10 years prior to the survey. (b) Awareness of the impacts of natural hazard-related events on the local environment and personal health. (c) Beliefs about the influence of climate change on their local environment and the occurrence of natural hazards.

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Discussion

This study provides insights into how women in a climate-vulnerable setting, such as Indonesia, understand and respond to the health risks posed by climate change. While participants demonstrated strong concern and general awareness of climate-related environmental impacts, such as pollution, extreme weather, and rising temperatures, significant gaps were observed in their understanding of how climate change affects women's and children's health. Notably, knowledge of specific issues such as preterm birth, domestic violence, and sexual violence was limited, even among highly educated respondents. These findings echo global concerns raised by the IPCC Sixth Assessment Report, which notes that women and children are disproportionately affected by climate-related health impacts due to systemic inequalities in access to information, services, and decision-making power [1]. Consistent with the WHO Global Strategy on Health, Environment and Climate Change [6] and the 2025 WHO Global Action Plan on Climate Change and Health [2], our study reinforces the need for targeted, locally relevant public health education and messaging to improve climate and health literacy among at-risk populations. Collectively, our data reveals several key insights into the regional context, as outlined below.

Climate change and related health impacts

Our results suggest that higher educational attainment alone does not ensure adequate knowledge of climate-related health risks. While statistical analysis showed that knowledge of climate change causes was significantly associated with education level, knowledge of climate-related health impacts was not associated with education, occupation, marital status, and residence. This distinction suggests that formal education strengthens the general understanding of climate change as a phenomenon. However, it does not necessarily translate into awareness of its specific health consequences, particularly those affecting sexual and reproductive health and child development. Across all education levels, most women did not associate climate change with sexual and reproductive health outcomes, including menstrual disorders, gestational hypertension, preterm birth, and sexual violence, factors identified in the scholarly literature [15,22]. Awareness was also limited regarding the potential impact of climate change on child stunting [23]. In contrast, participants demonstrated greater recognition of the effects of climate change on respiratory illnesses, dermatological conditions, and vector-borne diseases such as dengue haemorrhagic fever [24]. The absence of demographic differences in climate-health knowledge suggests that these gaps are widespread rather than confined to particular socioeconomic groups. This finding further reinforces the need for population-wide climate and health public health communication strategies rather than narrowly targeted educational interventions.

Greater awareness of respiratory and infectious diseases may reflect lived experiences, particularly in managing personal or family health, as well as sustained media attention to these conditions [25]. In Indonesia, recent reporting on rising dengue cases and respiratory illness linked to changing weather patterns may have heightened public recognition of these risks. [26]. Such reporting has challenged the longstanding perception that dengue occurs only during the rainy season [24,27]. However, the comparatively low awareness of gendered and reproductive health impacts highlights a critical blind spot in both public discourse and health education.

The knowledge-attitude-practice patterns observed in this study reveal important inconsistencies. Although knowledge of climate-related health impacts did not vary significantly across demographic groups, positive attitudes toward climate change were associated with both education level and residence. In our study, women with higher levels of education and those living in disaster-prone geographic areas (coastal, lowland or highland) were more likely to express concern about climate change. Similar observations were reported in Thailand, demonstrating that women and individuals with higher levels of education are more likely to express concern about climate change and engage in climate-related actions [28]. Furthermore, a recent global study examining what drives public concerns about climate change identified that climate change concerns are predicted by education and direct experience of natural hazard disasters [29].

Mitigation practices, however, were shaped by broader social factors. Engagement in climate change mitigation behaviours was significantly associated with education, occupation, and marital status, but not residence. Previous research suggests that environmental behaviours are often influenced by socioeconomic characteristics such as education, employment, and income rather than knowledge alone [30]. Our findings suggest that while awareness of climate-health risks may be broadly distributed, translating that knowledge into action is influenced by social roles, economic participation, and household responsibilities. In many low- and middle-income settings, women's climate vulnerability and responses are shaped by gendered roles and caregiving responsibilities that influence their access to time, resources, and decision-making power [4,31]. In the Indonesian context, where women often serve as primary caregivers and household managers, occupation and marital status may therefore affect the capacity to adopt mitigation practices [10]. Our findings also suggest that improving knowledge alone is unlikely to generate sustained behavioural change without addressing structural and gendered constraints in Indonesia. Climate adaptation strategies must therefore move beyond information provision to include enabling policies and supportive environments that facilitate women's agency and participation [1].

Variation in climate-health literacy among women appears to be driven less by formal education and more by access to locally relevant and accessible information [32]. In our study, the internet emerged as the primary source of climate

change information for Indonesian women, which is consistent with the country's widespread use of WhatsApp and other social media platforms. In Indonesia, these platforms are commonly used not only for interpersonal communication but also for disaster coordination and information sharing [33]. While previous research suggests that urban women tend to rely more on media sources whereas rural women often learn through lived experience [34], our survey results suggest that web-based information is widely accessible across both urban and rural settings. Taken together, these findings suggest that population-wide public health education initiatives aimed at strengthening women's understanding of the full spectrum of climate-related health risks, particularly those related to sexual and reproductive health and child health, can be delivered through multiple channels. These may include social media platforms such as WhatsApp [25], as well as mainstream media, to support preventive actions that protect both maternal and child health.

Cultural and religious influences

Women's awareness of human-induced climate change closely paralleled the proportion who perceived climate change as both a natural phenomenon and as "God's will", reflecting the complex interplay between scientific understanding and spiritual worldviews. The perception that climate change is 'God's will' can diminish a sense of personal and collective responsibility for mitigation efforts, such as reducing greenhouse gas emissions or advocating for environmental policies [35]. It may also impede climate adaptation and resilience initiatives, and limit collaboration between religious leaders, scientists, and policymakers, thereby reducing opportunities to strengthen community resilience and mitigate climate change-related impacts [36]. Furthermore, moral and ethical considerations related to social justice may be affected when climate change is viewed as divinely predetermined, potentially reducing the perceived urgency to protect vulnerable populations, including women and children [37].

Although religious beliefs are sometimes viewed as a barrier to climate action, religious beliefs do not necessarily preclude environmental engagement. In Indonesia's Muslim-majority context, principles of Islamic environmentalism, -tawhid (unity), mizan (balance), khalifa (stewardship), and maslahah (public good), can actively support environmental responsibility and climate engagement [38]. Similarly, ecological repentance, as articulated in Pope Francis' *Laudato Si'* encyclical, emphasises moral responsibility and action in response to the climate crisis rather than passive acceptance [39]. However, the extent to which religious institutions operationalise such theological frameworks to promote environmental stewardship, intergenerational responsibility, and care for vulnerable populations remains unclear. Interestingly, participants did not identify religious institutions or schools as preferred sources of information. However, given Indonesia's high levels of religiosity [40] and strong educational infrastructure [41], engaging religious leaders and educational institutions may represent an underutilised avenue for strengthening public awareness of climate-health literacy and promoting climate action. Our previous research also identified the Indonesian Meteorological, Climatological, and Geophysical Agency and local community leaders as trusted channels through which public health education initiatives could be delivered [25].

Climate change mitigation and adaptation

Participants recognised the importance of tree planting as both a mitigation and adaptation strategy. They identified its role in moderating microclimates, regulating water flow, sequestering carbon, providing habitats, and supporting food security. This knowledge is particularly valuable given the ongoing decline of green spaces in Indonesia, especially in urban areas [42]. Although the Indonesian government has enacted legislation promoting environmental protection and green space preservation, such as Law No. 18 of 2013 on the Prevention and Eradication of Forest Destruction and Law No. 32 of 2009 on Environmental Protection and Management, implementation and monitoring remain insufficient for effective climate action [43]. Stronger enforcement of these policies could create greater opportunities for women's engagement in tree planting and broader environmental protection initiatives. It also remains unclear which community-led climate adaptation measures most effectively address the needs of women and children.

Policies and public awareness programs

Our findings indicate that although Indonesian women are eager to learn more about climate change and climate action, they have a clear expectation that the government should take primary responsibility for addressing climate impacts and providing region-specific guidance. This expectation aligns with Indonesia's National Action Plan on Climate Change Adaptation (RAN-API) [44]. However, a gap persists between policy intentions to support community adaptation and resilience and how communities experience and respond to these policies. In our study context, this gap includes addressing community expectations while supporting adaptation efforts that respect cultural and spiritual ties to place.

Our survey findings suggest that residential location shaped perceptions of climate impacts, with coastal, riverine, and highland communities describing distinct environmental and health challenges. These findings reinforce the importance of geographically tailored public health interventions that respect cultural ties to place while addressing local vulnerabilities, as climate-related health risks vary substantially across ecosystems and social contexts [45,46]. At the same time, the lack of association between residence and mitigation practices suggests that structural and social factors may outweigh geographic exposure in determining behavioural responses, as pro-environmental behaviours are often shaped by socioeconomic characteristics, environmental identity, and social norms rather than environmental exposure alone [30,47]. These observations are further supported by reports that women living near rivers, lowlands, and coastal areas were generally aware of increased health risks, including skin conditions and heightened dengue fever exposure [48]. Effective adaptation therefore requires both place-based strategies and attention to the social determinants that shape behavioural responses, meaning that public health interventions must be culturally and geographically tailored to address local vulnerabilities while supporting communities in maintaining cultural identity and connections to ancestral lands [1,9,49,50].

Implications for gender-responsive climate action

Collectively, our findings respond to global calls for gender-responsive climate and health strategies articulated in the 2025 WHO Global Action Plan on Climate Change and Health [2]. The identification of climate-health knowledge gaps, combined with socially patterned attitudes and practices, suggests that adaptation efforts in Indonesia must integrate three components: 1) Comprehensive climate-health literacy, particularly regarding sexual and reproductive health and child development; 2) Structural support for behavioural change, addressing occupational, household, and social constraints; and 3) Multi-sectoral collaboration, engaging healthcare providers, community leaders, educators, faith-based organisations, and trusted public institutions to support women in proactive practices in climate change mitigation.

Strengthening primary healthcare platforms, such as Primary Healthcare Centres (Puskesmas) [9,51], community health workers and women-focused health promotion services such as the Integrated Health Service (Posyandu) [52] and Maternal and Child Health Programs [53], offers a practical avenue for integrating climate-health education into existing systems. Leveraging digital platforms and widely used communication channels, such as WhatsApp, can further improve reach and accessibility [25]. Finally, integrating climate-health education into primary and secondary school curricula in an age-appropriate manner [54] could further strengthen long-term adaptation and resilience by increasing awareness of climate-related risks to women's and children's health. School-based climate and health education has been shown to improve knowledge and awareness of climate-related health risks and build skills relevant to climate adaptation [54]. Such approaches align with global climate policy frameworks that emphasise education and awareness-raising as key mechanisms for strengthening adaptation capacity (United Nations SDG 13.3) [5]. By providing baseline evidence on women's climate-health knowledge, attitudes, and practices, our study contributes to efforts to operationalise gender-sensitive, risk-informed adaptation strategies at national and regional levels. More broadly, the findings have relevance to other low-resource, climate-vulnerable settings where women play a central role in household health and adaptation decision-making.

Limitations

This study primarily collected data through an online survey, which may have limited accessibility and reduced the representativeness of the findings for the broader population, as web-based surveys can exclude individuals without internet access or digital literacy [55,56]. To mitigate this limitation, the research team travelled to vulnerable rural and urban communities to collect responses in person and to assist participants facing literacy challenges. Self-selection bias is also possible, as participation in the survey was voluntary and respondents may differ systematically from non-participants [57]. Although time, budget, and resource constraints did not limit the conduct of this study, the survey consisted primarily of closed-ended questions. As a result, the absence of qualitative data restricted contextual depth and required reliance mainly on statistical analysis and cross-referencing, as structured questionnaires provide limited insight into participants' perspectives and experiences [58]. Additionally, participants were not required to complete all survey sections, leading to incomplete responses to some health impact questions and limiting the interpretation of certain findings, as missing survey data can reduce statistical power and affect inference [59]. These limitations will be addressed in planned follow-up studies designed to explore the lived experiences of stakeholders involved in women's and children's health using qualitative methods that allow deeper contextual understanding [60].

Conclusion

This study responds to urgent global calls to prioritise gender and health equity in climate change adaptation. By examining how climate-vulnerable women perceive the impacts of climate change on women's and children's health, as well as their access to health-related information, these findings provide a foundation for designing targeted interventions aligned with international frameworks, including the Sustainable Development Goals [5], UNFCCC Gender Action Plan [4], and the WHO's Global Action Plan on Climate Change and Health [2]. Strengthening these efforts is essential to ensuring no one is left behind in the face of unabated climate change.

Our assessment of women's knowledge, attitudes, and practices identified critical gaps, particularly in relation to preventive measures and sexual and reproductive health, that may limit women's capacity to engage in climate action and build resilience. Given that women are primary caregivers in Indonesia, their ability to support their families' health needs and respond effectively to extreme weather events depends on improved access to knowledge, resources, and supportive systems [10,16]. Addressing these gaps requires multifaceted public health strategies that integrate healthcare services with accessible information channels, including mainstream media, digital platforms such as WhatsApp, and community networks. Collaboration across the education sector, faith-based organisations, and government institutions will also be essential for developing, implementing, and evaluating climate-related policies that safeguard the health of women and children in Indonesia.

Supporting information

S1 Checklist. STROBE checklist. STROBE checklist reporting guidelines.
(DOC)

S1 File. Analysis. Statistical analysis of questionnaire data.
(PDF)

S1 Data. Raw questionnaire data.
(XLSX)

S1 Table. Knowledge, attitude, practice and source of information about climate change questionnaire.
(PDF)

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